
Glacier National Park was established by congressional legislation in 1910. The National Park Service (NPS) was created shortly thereafter to administer the national parks in a way that would “conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations.” Glacier falls directly under the stewardship provision of this act.

When it was built, more than 60 percent of the excavation for the Road was through solid or partially fractured rock. Nearly two million cubic yards of material had to be removed and 22,400 linear feet of culvert pipe laid during construction that culminated in 1932. From 1932 to 1957, the Road received extensive improvements including widening, asphalt surfacing, construction of additional stone masonry retaining walls and guardwalls, new bridges, slope stabilization, and drainage improvements. Since 1957, limited reconstruction or rehabilitation work has been done in the alpine area. In recent years, the NPS has been working with the FHWA on the design and rehabilitation of critical retaining walls.

As public support and resources are devoted to the rehabilitation of the Going-to-the-Sun Road, it is in the public interest to maintain and protect the capital investment and historic value represented by this national resource. To this end, the following text provides observations and recommends maintenance and operations concepts that will assist Glacier in addressing the needs of the Road.

Protection of the Road and the capital, historical, and recreational importance it represents, should be accorded the significance due a world-class visitor destination and National Historic Landmark. In order to do this, it is imperative that sufficient funds and other resources be allocated to sustain a fully staffed, fully funded, and fully functional maintenance program tailored to the specific needs of the Road. The importance of ongoing roadway maintenance is illustrated in Figures 116 and 117. These figures chart the cost or worth of a roadway over time.

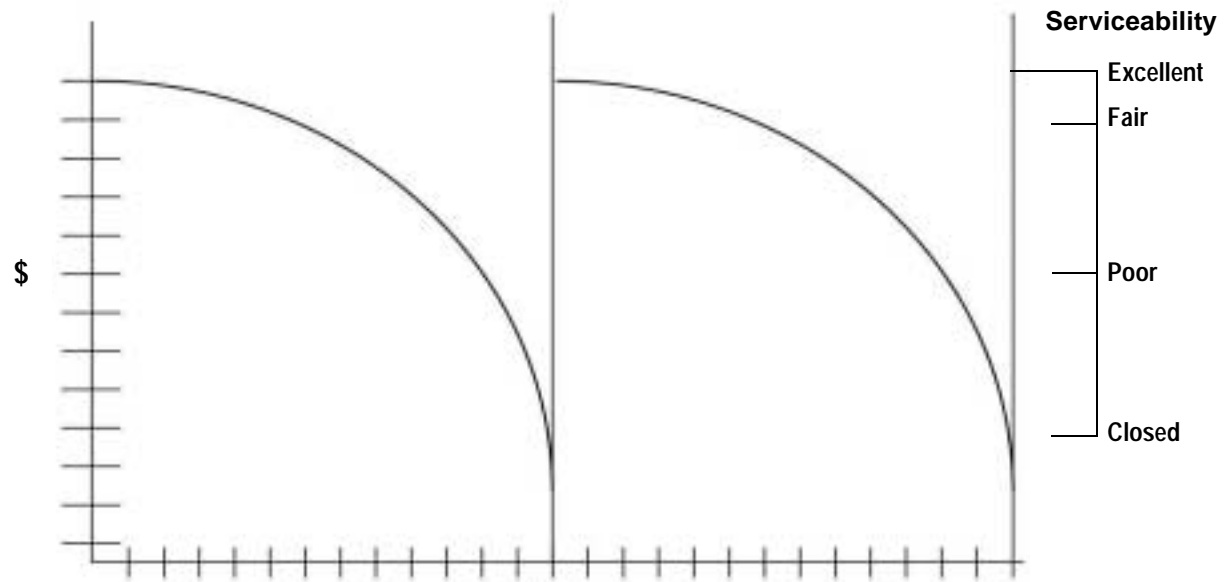


Figure 116: Roadway Costs or Worth (\$) vs. Time, Very Little or No Maintenance

Source: FHWA

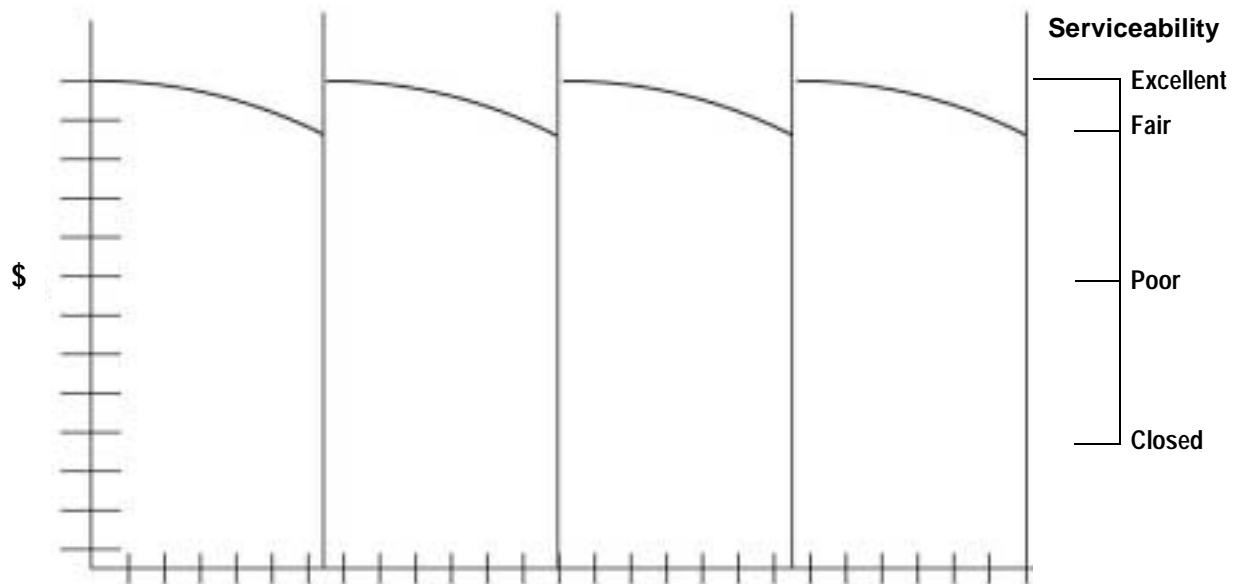


Figure 117: Roadway Costs or Worth (\$) vs. Time, Regular Maintenance

Source: FHWA

The initial construction cost or worth of a roadway system is shown on the vertical axis, and the passage of time is shown on the horizontal axis on both graphs. As shown, the rate at which a roadway deteriorates increases over time. If maintenance needs are continually left unattended, the serviceability or worth of the roadway will decrease at an accelerating rate and the cost of rehabilitation will soon approach the initial cost of construction. Conversely, if maintenance needs are met in a timely and adequate fashion, the serviceability of the roadway can be upheld at a fraction of the cost of periodic roadway reconstruction.

Historic Maintenance Practices

Glacier National Park maintenance supervisory personnel were interviewed, and the park archives and historical documents were researched for information regarding historical maintenance practices. From this research, it was determined that throughout the early history of the Road, and extending through the years until as recently as the 1980s, maintenance crews did not have the proper understanding of the Road's historic elements. Guardwalls were regarded as snowplowing hazards and were left to deteriorate.

Although maintenance activities are better planned and executed now, maintenance work was initially performed with relatively primitive equipment and poorly trained personnel. Many activities proved to be very difficult, time and labor intensive, and hazardous to the workers. Historically speaking, very little concern was expressed or care taken to safeguard drainage facilities, stone masonry walls, the pavement structure, or other roadway features. Snow removal was particularly difficult due to the ever-present danger of avalanches and the fact that the workers had to "feel" their way down to the pavement through many layers of packed and often very unstable snow. Equipment blades and tracks often gouged into the pavement and the stone guardwalls, causing considerable damage. In most cases, rock, mud, and debris slides were simply pushed over the side of the roadway, occasionally taking sections of stone guardwall along with them. Drainage facilities were allowed to deteriorate and become plugged or otherwise inoperative.

Poor maintenance practices and diminishing maintenance resources led to further deterioration and failure of many historic and service features. The park roadway maintenance staff full time equivalency (FTE) fell to less than half of the personnel needed, while the park experienced an average visitation increase of well over ten percent per year through 1984. As resources diminished, roadway repair and mainte-

nance activities of necessity became more reactive than proactive. This has continued into the present, and is a major cause for concern as the Road continues to deteriorate, and loss of services and historical features becomes more and more evident.

Current Maintenance Practices

Visual observations and further discussions with Park Service personnel indicate that since the mid 1980's park maintenance personnel have developed a significantly better appreciation for the historical, environmental, and functional significance of the Road. Snow removal techniques have improved to safeguard personnel and roadway facilities through use of specialized equipment and trained and experienced personnel. Rock and mud debris are no longer indiscriminately cast over the side of the Road, but rather hauled to an approved disposal site where they are often utilized as new material for roadway or wall repair work. Operations and safety training are readily available for staff personnel, and efforts are made to retain specialized personnel in order to maintain continuity of operations. A monthly road maintenance work schedule has been developed by the NPS in order to best utilize the limited resources available (Appendix F). A *Roadside Maintenance Guideline* has also been developed by NPS for direction in maintenance work (see Appendix G).

Still, funding levels and allocation are so inadequate that little maintenance beyond snow and rock removal is accomplished. For example, according to park personnel, the entire budget allocated for roadway maintenance activities within the park for the year 2000 was \$562,000. Approximately \$280,000 was allotted to the Going-to-the-Sun Road, of which \$153,000 was spent on spring opening and \$127,000 on Road maintenance activities. As a consequence of this low maintenance allocation, many critical elements including drainage; repair of historic guardwalls, retaining walls, and structures; slope stability, and the Road's traveling surface have not been maintained.

Operations and Maintenance Preservation Plan

An analysis and recommendation for operations and maintenance support for the Road is an integral part of this Engineering Study. Revisions to the park's Operations and Maintenance Plan should draw upon the information in this study and past studies that addressed operations and maintenance. Past studies include the 1984 FHWA *Road Rehabilitation Planning Study*, various inventories on retaining walls, guardwalls, and drainage, and the 1993 Glacier National Park *Roadside Maintenance*

Guideline. The *Roadside Maintenance Guideline* recognizes the park's commitment to maintain the roadway "in a way that protects the structure and integrity of the Road, avoids or minimizes damage to natural resources, maintains or improves roadside safety, protects cultural resources, and recognizes the importance of the visitor experience."

Due to the many and varied needs of Going-to-the-Sun Road, it is highly recommended that the NPS continue to maintain a dynamic and practical operations and maintenance program. The Operations and Maintenance Preservation Plan should be specific to the climatic and physical attributes of the Road, as well as consistent with NPS policy and general management plans. The elements considered in the plan should include the following, with each topic discussed in detail:

- Determination of Needs and Maintenance Activities
- Resources: Labor, Equipment, and Materials
- Operational Procedures
- Cost Accounting and Funding
- Ecosystem Considerations
- Innovative Techniques

Determination of Needs and Maintenance Activities

Operation and maintenance activities should continually be assessed, quantified, and prioritized. With only emergency repairs scheduled for the Road in the next few years, it is essential to assess current needs and develop a prioritized list of maintenance activities. The information provided in this study regarding deficiencies and recommended solutions provides a good source to determine what work could be undertaken as a function of maintenance. An overall prioritization is presented below for consideration:

- Ensure safety of the traveling public
- Provide emergency traffic control and services when needed
- Slow deterioration by addressing drainage and erosion
- Preserve natural resources
- Minimize impact to the Road during snow removal
- Maintain infrastructure for critical structures
- Provide localized pavement sealing
- Provide general maintenance and repairs based on priority list

- Monitor geotechnical instrumentation
- Inspect features of the Road and identify deficiencies
- Maintain a log of deficiencies with priorities and schedule

As the Road and its features age and deteriorate due to environmental and weather conditions and vehicular usage, maintenance and rehabilitation costs become more and more of a factor in protecting the capital investment and historic nature of the Road. Regular roadway inspections and monitoring programs should be developed and implemented in order to monitor roadway conditions and provide a basis for continuing maintenance operations.

Glacier should also develop a roadway and Pavement Management System (PMS) that recognizes the needs of the park and the traveling public, and organizes park staff, facilities, and other resources consistent with those needs. The FHWA has been a strong advocate of PMS over the past decade and would be an excellent source of assistance in this program. The basics for this management system already exist in the management studies and park management plans that are available throughout the NPS.

Resources: Labor, Equipment, and Materials

Labor. Normal Road maintenance functions involve a wide array of activities ranging from basic labor such as debris or litter removal and assistance in culvert repairs, to highly skilled and specialized tasks such as engineering analysis and repair of bridge structures or stone masonry walls. Maintenance personnel must be familiar with the operation of common and specialized equipment, and be cross-trained in a variety of activities commensurate with their duties. They should also have a respectful knowledge of environmental, historic, and aesthetic values as per NPS policy, and be able to interface with the traveling public as official representatives of the NPS.

Human resources personnel can be either full-time or seasonal employees, or specialty work can be contracted to individuals. It would be best to have a regular, full-time maintenance staff, as retaining their knowledge, wisdom, and experience within the park is essential to an effective program. If full-time employees are not feasible, the use of contracted maintenance is vital.

As is the case with existing FHLP contracts, it may be more advantageous to contract out certain maintenance operations that are sporadic in nature or otherwise impractic-

cal for regular in-house staff to accomplish. Many factors affect the practicality of this procedure, and should be carefully considered by management and staff personnel. A number of these factors have been listed in Glacier's *Road Maintenance Program*, where certain "core" capabilities essential to the park's well being have been identified. The 1984 FHWA study identified core activities for "in-house" operations in order to provide timely and efficient maintenance services with a minimum of disruption to park visitors. Many of these activities require immediate, on-site value judgments by NPS personnel. The FHWA study also identified other activities for potential contract work, such as application of pavement seal coats, roadside mowing, and pavement striping. Contract maintenance could be performance-based. Another option is to add maintenance functions onto the rehabilitation contracts during the rehabilitation of the Road.

With any form of labor, it is necessary to have the proper training to conduct the work. Experienced individuals in drainage, slope stability, and traffic control should continue to be available as part of the maintenance crew to respond to emergency needs in a timely and efficient manner. These individuals should be competent, not only in the proper conduct of their normal duties, but also in health and safety measures that may be required during emergencies.

Equipment. Although it may be a cliché, using the right equipment for the job is the overriding recommendation. State-of-the-art equipment and procedures should be available to park maintenance personnel at all times. Commercial industry could be very helpful in taking an idea or expressed need (provided by the park) and developing innovative equipment and procedures to accommodate that need. On occasion, manufacturers may provide such equipment at a discounted cost in return for "proving the worth of the equipment" and partnering with an agency in its use.

Materials. Both manufactured and natural material sources should be identified and secured. These sources should be readily available or stockpiled for roadway maintenance functions. Commercial material sources should be solicited and encouraged to bid on material supply contracts commensurate with park needs.

In order to preserve the historic significance and appearance of park facilities in an appropriate manner, as well as to preserve the natural resources of the park, it would be advantageous to utilize certain sites within the park as sources for naturally occurring material. For example, stone removed from the roadway and downhill slopes, and rock from rock scaling operations, could be used for stone masonry wall repairs.

Operational Procedures

Over the years, individual NPS units (parks, monuments, etc.) have developed comprehensive maintenance programs that are generally well-conceived and designed to accommodate the specific needs of each unit. In Glacier, the maintenance program is guided by the *Glacier National Park Road Rehabilitation Planning Study* and the *Roadside Maintenance Guideline*. Both of these documents recognize the variability of roadway maintenance needs throughout the park and promote maintenance management practices commensurate with those needs. These documents provide a good basis for operations and maintenance, and should be updated as necessary and continue to guide the park's maintenance of the Road. The park has also developed a comprehensive *Road Function Analysis* that identifies certain roadway maintenance categories and sub-categories. This analysis is also considered thorough and well-conceived, and should continue to be used as a management tool.

The following recommendations outline proposed strategies and procedures that are compatible with and that may supplement existing operations.

- To maintain continuity of services, a single Maintenance Supervisor or Facilities Manager should be responsible for overall management of maintenance activities on the Road. The Supervisor's office should be located within the park headquarters facilities to maintain timely and productive liaison with the Park Superintendent, Park Rangers, visitors, and other concerned individuals. This is currently the case.
- Due to the differences in climate and terrain between the eastern and western sides of the park, and the potential for traffic disruptions over Logan Pass as a consequence of weather conditions or other natural occurrences, two separate field maintenance offices or districts should continue to be maintained to assure uninterrupted service. In addition to normal maintenance functions throughout the rest of the park, the Eastern office would continue to service the Road from its eastern terminus to the top of Logan Pass and, the Western office would provide similar services from the Road's western terminus to the top of Logan Pass.
- Each district office should carry a complete staff of properly trained and qualified personnel under the direction of a District Maintenance Chief or foreman who would be directly responsible to the Maintenance Supervisor.
- Each maintenance activity should be analyzed and charted showing the type of activity and the anticipated personnel hours and other resources required to complete it.

- To maintain the proficiency of the staff, especially with respect to unique work such as repair of historic stone masonry walls or spring snow removal through the alpine section, efforts should be taken to retain qualified individuals insofar as practical. These efforts could include cross-training of employees and sharing employees with other NPS or nearby state offices where seasonal or part-time needs are compatible with Glacier's needs.
- The park has developed a set of "Most Efficient Operations" (MEO) plans to provide optimum utilization of staff. These plans should be updated as necessary and should be made a key part of management decisions.
- Necessary equipment and supplies should be readily available to each office in order to carry out assigned functions. This equipment could be either owned outright or rented by contract agreement through private or commercial sources. The practicality and availability of rental equipment should be carefully considered, versus outright ownership.
- Equipment maintenance facilities should be readily available and well equipped. Also, mechanics and fleet personnel should be properly trained and qualified.
- Proper equipment housing or storage facilities should be provided to each field office and a current inventory of equipment should be maintained. Realistic equipment usage costs and rates should be established in order to effectively manage these resources.
- Emergency procedures, skills, and equipment should be developed and available specific to the remote alpine conditions prevalent throughout the length of the Road.
- Employee training should provide each employee with the technical skills and abilities needed to perform the maintenance operations under his or her jurisdiction. This should include special training in communication skills and working with the traveling public.
- Safety training, awareness, and actions should always be foremost in any comprehensive maintenance and operations plan. This plan should address the vulnerability of both the park staff and the traveling public to hazardous conditions throughout the park. The proper use of traffic control personnel and safety devices should be included as standard operating procedures at all times.
- A rehabilitation crew should be established to make repairs and minor rehabilitations to the Road on an ongoing basis, similar to the crew that existed in past years. The crew's primary function would be to slow the deterioration of the Road until the overall rehabilitation effort can commence, and afterwards, provide the

repair and rehabilitation on small segments of roadway that are remote from the major areas in need of rehabilitation. After the major rehabilitation effort is complete, the crew could continue with standard maintenance activities.

The crew should be multi-disciplinary and include stone masons, small-equipment operators, and laborers. The crew would be seasonal in nature, but should be consistent from year to year if possible, especially in the supervisory and masonry work. The work to be accomplished by the crew could include:

- inspection, monitoring and record keeping of conditions of drainage, roadway, guardwalls, retaining walls, and slope stability
- cleaning out, maintenance, and minor repair of inlets, culverts, concrete box culverts, and other drainage devices
- maintenance and minor repair of guardwalls, retaining walls, and other stone masonry structures
- minor rock scaling
- collection and caching of rocks for stone masonry rehabilitations
- traffic control operations during emergency situations and repairs
- roadside assistance for disabled vehicles
- maintenance of safety equipment and barriers

Equipment available to the crew should include trucks, a bobcat loader, an air compressor, a jackleg, air tools, masonry tools, a slusher or winch, traffic control equipment, roadside assistance equipment, small firefighting equipment, and communications equipment

Crew training should include safety, inspection, geotechnical monitoring, historic and environmental considerations, bio-remediation, traffic control, masonry, rock scaling, equipment operation, and small firefighting.

Cost Accounting and Funding

The operations and maintenance plan should set up a comprehensive cost accounting system for each district and each maintenance activity. This system should be based on reference locations from a re-survey and standard stationing of the Road,

which will allow the development of a maintenance history for the entire roadway. This information would be very useful in analyzing maintenance activities and in documenting funding requests respective to a viable roadway maintenance program.

For the Road to be properly maintained, it is imperative that adequate funding resources are identified and allocated on a continuing basis.

Table 3 contains a brief estimate of the salary requirements to fully staff a maintenance program for one year for the Going-to-the-Sun Road. These burdened rates, as coordinated with Glacier National Park, include 30% benefits and 40% overhead factors. The total estimated costs are further broken down to reflect the amount of time attributable to the Going-to-the-Sun Road considering the seasonal nature of the Road's maintenance. All figures are in Year 2001 dollars.

As calculated in Table 3, the base adjusted salary cost for regular maintenance operations for the Going-to-the-Sun Road is estimated at just over \$450,000 per year. It is further estimated that the cost of vehicles, construction and maintenance equipment, yard supplies, and operating costs (fuel, oil, filters, replacement parts, etc.), can be expected, according to FHWA data, to average two to three times the value of personnel resources. This results in an additional cost of \$900,000 to \$1,350,000 per year. Also, early spring snow removal costs and preparations for visitor traffic require an additional \$130,000 or more. Considering each of these elements, the total amount required for annual maintenance of the Road is estimated at approximately \$1.5 million to \$1.9 million per year.

Table 4: Annual Human Resource Funding Needs for Maintenance of the Road

Position	Number Required	Burdened Annual Salary	Total Cost per Position	Total Cost per Department per Year	Portion of Year Spent on GTSR	Actual Cost to GTSR per Year
Maintenance Manager	1	\$124,100	\$124,100	\$124,100	1/2	\$ 62,050
Maintenance Supervisors	2	91,800	183,600	183,600	1/2	91,800
Drainage Maintenance Crew						
Foreman	1	74,800	74,800			
Laborer	2	40,800	81,600	156,400	1/3	52,133
Masonry Crew						

Table 4: Annual Human Resource Funding Needs for Maintenance of the Road

Position	Number Required	Burdened Annual Salary	Total Cost per Position	Total Cost per Department per Year	Portion of Year Spent on GTSR	Actual Cost to GTSR per Year
Stone Mason	1	68,000	68,000			
Apprentice	1	50,000	50,000	118,000	1/3	39,333
Equipment Operator and Servicing Technician	2	72,250	144,500	144,500	1/2	72,250
Brushing Crew						
Operator	1	72,250	72,250			
Laborer	1	40,800	40,800	113,050	1/3	37,683
Office Support Staff						
Secretary	2	51,000	102,000			
Storekeeper	2	45,000	90,000	192,000	1/2	96,000
TOTAL BURDENED PERSONNEL SALARY COSTS						\$451,249

Alternate sources to fund this maintenance might include imposing a toll or usage fee upon commercial and visitor traffic, solicitation of community and private involvement in supporting specific projects within the park, public relations campaigns to encourage public interest and donations for roadway upkeep and rehabilitation, local political and commercial support for maintenance needs, investigation of potential grants or commercial advertising resources, and involvement with universities or study groups interested in “partnering” with the park in various activities.

Ecosystem Considerations

Due to the complexity of the park’s ecosystem, several items should be carefully considered in the operations and maintenance plan with guidelines prescribed to avoid adverse environmental impacts. Terrestrial and aquatic plant, animal, and insect life should be identified and taken into account with respect to maintenance activities, especially in terms of the schedule of work. A procedure for the storage and use of chemical agents such as herbicides, roadway de-icing chemicals, and insecticides

must be carefully formulated, clearly understood, and adhered to in accordance with park policy. Toxic materials such as gasoline, diesel fuel, lubricants, paint, preservatives, asphalt, solvents, cleaning agents, etc. should be properly stored and utilized under strict control. Naturally or artificially generated waste material such as rockfall debris, mud, or overburden must be properly disposed of or reused. Roadway side slope or bank protection and water flow restrictions must be adhered to in order to preserve the roadway infrastructure and properly control sedimentation and potential contamination of water resources. Noise, dust, smoke, fumes, or other particulates must be minimized.

Innovative Techniques

Innovative technological advancements and state-of-the-art maintenance practices should be considered through all phases of design and rehabilitation work in order to provide “maintenance friendly” roadway facilities. Some of these concepts have been already implemented and could be expanded into established practices. These practices could include:

- design of crossroad drainage facilities accessible to and wide enough for machine cleaning
- expanding the installation of metallic cables, as was recently accomplished on Logan Pass, along the roadway centerline and/or edges to activate horizontal and vertical position sensors mounted in snow plowing and maintenance equipment
- continuing the installation of small sockets along the inside edge of structures to receive brightly painted snow marker poles for locating structures during snow removal operations
- using a bridge stripping buggy with some modification for guardwall and retaining wall inspection and refurbishing work as a component of the maintenance department’s equipment inventory
- using innovative rockfall detection devices and other protective measures to enhance maintenance personnel safety
- establishing rock and debris catch basins or diversion devices where appropriate
- using high-strength resilient plating to refurbish box culvert linings
- using Global Positioning System (GPS) satellite-based equipment and technology for roadway inventory, mapping, and equipment positioning

- installing geotechnical instrumentation to monitor the deterioration and stability of critical retaining walls
- expanding use of removable drainage access components for easy cleaning of culverts

Many of the practices listed above could be incorporated directly into the design and construction phases of roadway rehabilitation. This would promote effective maintenance on both a short-term and long-term basis, and would relieve maintenance budgets and operations from costly retrofit work. Careful design would be required to minimize any impact on the historic features of the Road.